Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 43 (2019) 147–155

Transportation Research Procedia

www.elsevier.com/locate/procedia

8th International Conference on Air Transport – INAIR 2019
GLOBAL TRENDS IN AVIATION

Flightpath 2050 revisited – An analysis of the 4-hour-goal using flight schedules and origin-destination passenger demand data

Wolfgang Grimme[a,]*, Sven Maertens[a]

[a] *German Aerospace Center (DLR), Institute of Air Transport and Airport Research,Linder Höhe, 51149 Cologne, Germany*

Abstract

Key benefits of aviation are the provision of connectivity and the reduction of travel times compared to other transport modes. The High Level Group on Aviation Research has laid out in its Flightpath 2050 document the goal that "90% of travellers within Europe are able to complete their journey, door-to-door within 4 hours". To our best knowledge, this objective has not been further specified in any other official document. The wording leaves considerable room for interpretation when assessing the level of goal achievement. We discuss different approaches for interpretation and apply a connectivity modelling approach to examine the respective degree of goal achievement. For the analysis, we use flight schedules and origin-destination passenger demand data at airport-pair level. Different assumptions on airport access and egress times have been made in order to simulate the door-to-door travel chain. In contrast to very detailed studies on the topic, conducted e.g. by the project DATASET2050, our methodology can be applied easily on available demand and schedules data, so that the progress of the 4-hour-goal can be monitored quickly. Moreover, our approach allows for a quick analysis of sensitivities. We find that a relatively large share of intra-European air passengers travel over distances where the 4-hour-goal cannot be achieved realistically, as even when non-stop flights exist, distances are too far to accomplish a trip within four hours with speeds of sub-sonic passenger aircraft. Moreover, an improvement of connectivity with more non-stop flights seems to be limited, as already today, about 93.5% of intra-European travellers fly on non-stop flights. Limited improvement could be achieved in accelerating airport processes or in applying small air transport / air taxi concepts from smaller airports, which could reduce airport access and egress travel times and distances.

Peer-review under responsibility of the scientific committee of the 8th International Conference on Air Transport – INAIR 2019, GLOBAL TRENDS IN AVIATION

Keywords: Flightpath 2050; connectivity

* Corresponding author. Tel.: +49-2203-601-2459
E-mail address: wolfgang.grimme@dlr.de

2352-1465 © 2019 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of the scientific committee of the 8th International Conference on Air Transport – INAIR 2019, GLOBAL TRENDS IN AVIATION
10.1016/j.trpro.2019.12.029

1. Introduction

Key benefits of aviation include the provision of connectivity and the reduction of travel times and travel costs compared to other modes, which can translate in (regional) economic growth. Among others, Bel and Fageda (2008), Gillen et al. (2015) or Dimitriou and Sartzetaki (2018) demonstrate different forms of positive impacts of air transport supply and connectivity on, e.g., business location decisions, firm productivity, jobs and tourism. However, unlike other areas in air transport, it is rather difficult to create meaningful indicators for connectivity and its impacts. On the one hand, the construct of connectivity is pretty abstract, and a large amount of different definitions, measures and indicators has emerged. For example, connectivity can be measured at a location (e.g. airport, country or region), or at network level (Burghouwt and Redondi, 2013; Maertens et al., 2016).

On the other hand, air transport connectivity has widespread, long-term and diffuse effects in various areas, where a direct cause-and-effect relationship is difficult to measure. On the one hand, air transport connectivity has a direct effect for its users, resulting in increased convenience when travelling and, most of all, savings in travel times compared to other modes. On the other hand, also non-users benefit from air transport connectivity, e.g. through an increase in attractiveness of a location, which results e.g. in increased tourism or the location decision of businesses. Hence, also non-users can benefit with employment, better pay or locational rents from the air transport system (for an overview and classification of such effects, see ATAG, 2005). The political aims for the development of the economy in the EU (European Commission, 2010) are also reflected in air transport. In 2010, a new strategic vision for aeronautics, named "Flightpath 2050", was developed by a high level group on aviation research with a horizon for the year 2050 (Krein and Williams, 2012).

The results of the high level group were published in 2011 (European Commission, 2011) and contain strategic objectives in five major areas "Meeting societal & market needs", "Maintaining and extending industrial leadership", "Protecting the environment and the energy supply", "Ensuring safety and security" and "Prioritising research, testing capabilities & education". In the area of societal and market needs, the high level group defined the following objective for the year 2050 (European Commission, 2011), which is henceforth referred to as "Flightpath 2050 4-hour-goal":

"90% of travellers within Europe are able to complete their journey, door-to-door within 4 hours"

To our best knowledge, however, this objective was never further specified in any official document. In the 2017 update to the Strategic Research and Innovation Agenda (SRIA) of the Advisory Council for Aviation Research and Innovation in Europe (ACARE, 2017), it was at least outlined that the achievement of this target is to be monitored and door-to-door mobility performance is to be evaluated.

It is the aim of this paper to discuss different approaches on how the goal can be interpreted, and to present a methodology to measure the level of goal achievement. For the latter, we develop and apply a connectivity model which uses actual flight schedules and passenger demand volumes in Europe as inputs, along with realistic assumptions for airport access, egress and processing times. With this analysis, we contribute to the literature on connectivity evaluation in general and to the evaluation of the Flightpath 2050 4-hour-goal in particular.

2. Literature Review

There is a fair amount of papers and studies dealing with air transport connectivity measurement and impacts, including the sources mentioned in the previous chapter.

The most detailed study on the Flightpath 2050 4-hour-goal so far was the DATASET2050 project, conducted by a consortium consisting of Innaxis, EUROCONTROL, Bauhaus Luftfahrt and Westminster University. It was the aim of the project to analyse in detail the drivers of travel time for intra-European trips, and how the achievement of the 4-hour-goal could be improved. Part of the project was the analysis of the baseline to what extent the 4-hour-goal has been achieved already. Based on various assumptions and available datasets, the authors modelled average times and distributions for the five journey sub-segments "door-to-kerb (D2K), kerb-to-gate (K2G), gate-to-gate (G2G), gate-to-kerb (G2K) and gate-to-door (G2D)" (Innaxis, 2017), which add up to the total door-to-door (D2D) journey. Hereby, “kerb” is defined as the point where the passenger arrives at or leaves from the airport by other means of transport.

The findings are rather disillusioning (Innaxis, 2017): The authors found that only 10% of intra-European air passengers spend less than four hours door-to-door, with 6 hours as the approximate mean and 90% of travellers completing their journeys within 7.5 hours. The authors see the largest potential to speed up total D2D time in accelerating the K2G segment, i.e. in improving airport processes. What the study lacks, however, is a discussion of how the 4-hour-goal should be interpreted in terms of theoretically available vs. actual route choices of passengers.

In an earlier study, Nieße and Grimme (2014) had analysed the 4-hour-goal with the help of data from the European research project ETISplus (European Commission, 2012), which provided a complete origin-destination passenger demand matrix on small geographical scale. Taking into account all trips, irrespectively of distance or main mode of transport in the door-to-door travel chain, Nieße and Grimme found that 92% of trips can be completed within four hours. However, this result seems to be skewed, as trips on very short distances make up the majority of all trips – hence for a majority of region pairs, air transport would not be a reasonable transport mode. In addition to the ETISplus demand data, Nieße and Grimme also took a second approach for an assumption of theoretical travel demand, which was that every European citizen would visit any other European citizen. Taking into account this theoretical demand (defined as population product) for each NUTS-2 region, 22% of such trips could be completed within four hours.

The existing literature shows that there is a wide range of results concerning the achievement of the 4-hour-goal. The look on past studies reveals that the assumptions taken have a major impact on the result in any 4-hour-goal assessment.

3. Interpretation of the 4-hour-goal and modelling assumptions

When analyzing the 4-hour-goal, it is inevitable that assumptions need to be defined how the goal has to be interpreted. As the 4-hour-goal reads “90% of travellers within Europe are able to complete their journey, door-to-door within 4 hours” and no further specification is defined in official documents, at least three overarching issues arise.

The first issue concerns the **90% of travellers**. It is reasonable to assume that with “travellers” individual trips are meant. It needs to be defined, however, what kind of trips should be considered. Basically, one could consider all trips made within Europe, independently of distance or purpose, as it was done in Nieße and Grimme (2014). If this assumption was made, the 90% goal would most likely be achieved already today, as the vast majority of trips are relatively short urban and regional trips which can be accomplished by car or public transport within the 4-hour-time-limit. For instance, commuting across NUTS-2-region borders plays a significant role in overall trip generation (EUROSTAT, 2016). Even though the quality of ground transport infrastructure differs within Europe, it is reasonable to assume that any origin-destination pair in continental Europe of 200km or less, where the majority of trips is generated, can be accomplished by car within four hours except for cases where no fixed crossings exist over sea, as the modal change to ferries can increase travel times substantially. As the authors of the 4-hour-goal belong to a group of aviation experts, however, it is reasonable to assume that the set of trips to achieve the 90% goal should only apply to trips involving at least one aviation segment in the door-to-door travel chain. This assumption has also been made by the authors of the DATASET2050 project.

The second need for clarification concerns the geographical definition of **Europe**. A wide definition is e.g. applied by IATA (Europe as part of Tariff Conference Area TC2), which includes Iceland, Morocco, Algeria, Tunesia, Azerbaijan, Armenia and Georgia as well as Russian cities up to a longitude of 60° East, but not Cyprus (which is part of the Middle East TC area). As Flightpath 2050 is an initiative driven by the European Commission, we proceed in this analysis with the definition of Europe as the EU with 28 member states as of 2018.

The third question is related to the phrase “**are able to complete their journey**”. Does being “able to” mean that travellers should actually, i.e. in reality, have completed their trips within four hours, or would it be sufficient if there was a (theoretical) option to get from door to door within four hours? If the latter applies, it would be necessary to define the “permitted” transport modes. If, for instance, car transport in combination with air taxi / business jet charter is considered as valid option, many more city pairs will fall into the scope of the 4-hour-goal. As in reality, however, the use of air taxis is supposed to be outside the willingness or ability to pay for the vast majority of travellers, it is reasonable to assume that this mode was not within consideration when the goal had been defined. Therefore, aviation will be limited to scheduled passenger services. Car transport as access/egress mode is widespread in the forms of individual self-driving, kiss-and-ride or taxi, hence it should be – as the most time-efficient access/egress mode in most cases – considered as valid transport mode for airport access and egress within the scope of this analysis.

Regardless of these assumptions, there are good reasons why travellers – in reality – do not chose the theoretically fastest itinerary or mode of transport. Travellers typically trade off travel time for travel cost. When they attribute a lower value to travel time savings, it is rational for them to choose a slower but cheaper mode of transport, e.g. coach or train instead of plane or a transfer itinerary instead of a non-stop flight. Along the same rationale, an economic assessment is conducted when infrastructure investments are planned – only when the time savings (among other benefits of an infrastructure project) of expected users exceed investment and operational costs, a project should be realized. The authors of the DATASET2050 project address this aspect by discussing the (potentially very high) costs of speeding up travel between specific city or region pairs in Europe.

In the context of the 4-hour-goal, it would make sense that the wording "are able to" refers to the theoretical option to travel within four hours, but not necessarily to the revealed preference and actual mode choice of users. Hence, we look at the theoretically fastest option for travel between two airport pairs, irrespective of capacities, prices, availability or frequencies. Following this discussion, a slightly re-phrased 4-hour-goal, making clear our assumptions, could be the following:

"90% of trips involving at least one flight segment and car traffic as airport access/egress mode within and between the EU-28 member states could theoretically be completed door-to-door within 4 hours"

4. Data and Methodology

For the analysis of the achievement of the Flightpath 2050 4-hour-goal, we have taken the following approach:

Under the absence of up-to-date, freely available origin-destination passenger demand matrices on small geographical scale for all transport modes covering the complete EU area, our analysis is based on (airport-to-airport) origin-destination air passenger demand data provided by Sabre Market Intelligence (MI) (Sabre, 2014). Except for the U.S. Bureau of Transportation Statistics' DB1B "10% sample" of airline tickets, which however is limited to the US market, origin-destination air passenger volumes are not publicly available. The commercial Sabre database combines and adjusts MIDT (Marketing Information Data Tapes) booking figures, which stem from global distribution systems like Sabre, Travelport or Amadeus, with data from external air transport statistics and with estimations for increasingly important direct bookings. Sabre MI outputs include monthly passenger volumes and fares (by airline, booking/cabin class) at the segment (direct route) and origin-destination levels. Sabre air transport demand data were used for several papers and studies, and the quality of the passenger number estimates is usually considered as reliable (e.g. Intervistas, 2014).

Regarding airport access and egress as part of the total door-to-door travel time, we assume that all passengers have uniform travel times to the departure airport and from the arrival airport. However, we add a sensitivity analysis with varying airport access times from 30 to 120 minutes and egress times ranging from 15 to 60 minutes to test for the influence of airport access and egress times (including airport process times for check-in, security, border control and boarding) on the goal achievement. In the most generous interpretation of the 4-hour-goal, one could define the goal as achieved if all passengers, for whom a non-stop option was available, actually chose this option. We are aware that this is a theoretical assumption as, in reality, passengers choose, for various reasons (e.g. availability, price, schedule, preferred airline) not always the fastest option.

To check whether a non-stop flight connection exists, flight schedules between all airports in the EU for the complete year 2018 have been extracted. In total, scheduled passenger carriers served 425 airports with 12,693 airport pairs and 5.34 million flights. Out of these, 9503 airport pairs were served at least once weekly and 3434 airport pairs at a minimum of one daily flight. For all of these airport pairs, the shortest airport-to-airport flight times were extracted and combined with the number of passengers travelling on each airport pair. The resulting dataset allows to analyse how many passengers travelled on which distances and how long this typically takes.

As only data concerning actual airport-to-airport trips are available, assumptions concerning airport access and egress times have to be made, which depend on the distribution of passengers in the airport catchment area. The definition of airport catchment areas is not straightforward. Literally taken, an airport's catchment would include all locations where its local outbound passengers live, or which any inbound passengers intend to visit, weighted by frequency. Such an approach, however, has the drawback that empirical airport choice figures would be needed, which are usually available in airport passenger surveys only, which are not disclosed publicly. Hence, it is easier to define catchment areas based on standardized access times or distances. A paper by Rothfeld et al. (2017) which stems from the above-mentioned DATASET2050 project assesses access and egress times for a sample of 22 European airports using Google Maps. They found that average travel times depend significantly on the mode of transport (car vs. public transport), with car access times being in the range of 24-45min for six of the largest European airports, compared to public transit times of 55-95 min. With these empirical results, the assumptions shown in Table 2 can be interpreted realistically.

5. Results

In 2018, almost 550 million origin-destination passengers travelled by air within and between EU member states. Table 1 shows the breakdown of all passengers by number of stops/transfers. This is insofar of interest for the assessment of the 4-hour-goal, as almost every itinerary involving a transfer shall automatically exceed the 4-hour-limit. This is because two flights of one hour each and an assumed transfer time of 45 minutes in between will leave only 1 hour 15 minutes for airport access, process and egress times. In 2018, only 6.5% of origin-destination passengers within Europe had one or more transfers on their itinerary.

Table 1. Distribution of origin-destination passengers in Europe by number of stops, 2018. Source: (Sabre Market Intelligence).

Number of stops/transfers within the air transport system	Number of passengers in million	Passenger share
Non-Stop	513.78	93.47%
One-Stop	34.93	6.36%
Two-Stop	0.96	0.17%
Three-Stop	0.02	0.0%
Total	549.69	100.0%

Figure 1 shows the cumulative distribution of origin-destination passengers by distance. In 2018, 90% of passengers travelled less than 2196km on their air segment. In other words, more than 10% of passengers travel on airport pairs where the distance alone impedes the achievement of the 4-hour-goal. This is due to the speed of currently used sub-sonic aircraft. When analyzing the flight schedules of the year 2018, we find that the "scheduled speed", calculated by great circle distance in km divided by scheduled flight time in hours is dependent on flight distance and averages 517km/h for distances of 1000km, 628km/h for distances of 2000km and 693km/h of distances of 3000km (Figure 2).

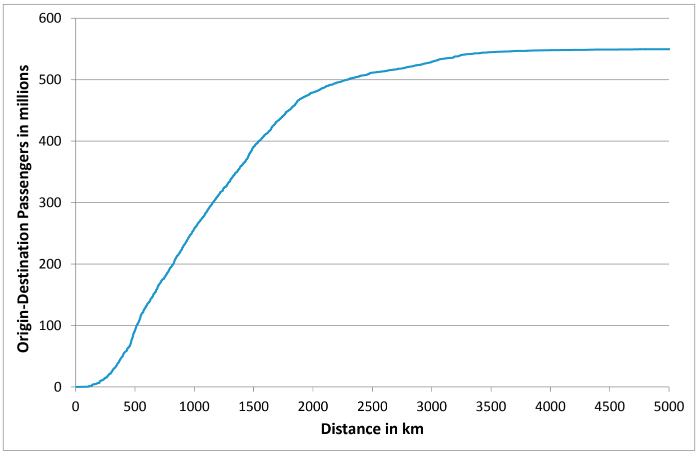

Fig. 1. Cumulative distribution of origin-destination air passengers by distance, 2018.

Hence, any trip exceeding a direct air distance of 2060km would automatically result in travel times exceeding 4 hours, even when we assume that airport access and egress time would not exceed 45 minutes in total. This would basically mean that the passenger's trip origin would be at the departure airport and the trip destination at the arrival airport, leaving no scope for any airport access/egress travel time when taking into account that passengers should arrive at the airport 30 minutes before departure and airport processes take at least 15 minutes after arrival until the passenger can leave the airport. At a combined airport access and egress time of 90 minutes (e.g. 60 minutes for airport access prior to scheduled departure and 30 minutes for airport egress after scheduled arrival), the maximum flight distance, which allows staying within 4 hours of total travel time would decrease to 1440km. For comparison, in 2018, 88.1% of passengers travelled 2060km or less and 67.4% of passengers travelled 1440km or less.

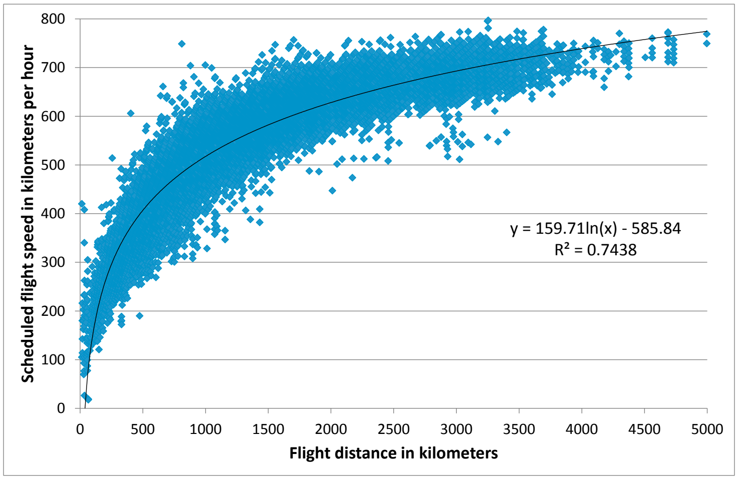

Fig. 2. Relation between flight distance and speed for intra-European flights, 2018.

Table 2. shows the main results under the following assumptions:

- If available, all passengers are assumed to choose a non-stop flight, irrespective of frequency, preferences for a particular departure time, airline or air fare;
- In case no non-stop connection is available on a particular airport pair, we assume that the maximum of four hours door-to-door travel time will be exceeded

The sensitivity of results towards these assumptions can be considered as very limited, as it was shown above that 93.5% of intra-European air travellers anyway have chosen a non-stop flight. So, the key parameter influencing the degree of goal achievement remains with the assumed airport access and egress times, including airport process times.

Table 2. Sensitivity of the degree of achievement of the 4-hour-goal towards variations in airport acesss/egress times.

		Airport egress & process time – minutes after scheduled arrival time			
		15 minutes	30 minutes	45 minutes	60 minutes
Airport access & process time – minutes before scheduled departure time	30 minutes	82.4%	79.0%	73.2%	64.8%
	45 minutes	79.0%	73.2%	64.8%	56.7%
	60 minutes	73.2%	64.8%	56.7%	47.9%
	75 minutes	64.8%	56.7%	47.9%	39.0%
	90 minutes	56.7%	47.9%	39.0%	28.9%
	105 minutes	47.9%	39.0%	28.9%	17.6%
	120 minutes	39.0%	28.9%	17.6%	5.9%

In order to evaluate the sensitivity analysis and to interpret the results, it would be valuable to know the actual distribution of airport access and egress times. However, the availability of such data is generally weak. The geographical distribution of air passengers is usually analysed by airport operators with the help of surveys, typically conducted in the course of market research with very limited public availability. Few examples in the European literature provide evidence on the distribution of passengers in the catchment area. Wilken, Berster and Gelhausen (2007) find in their analysis based on the consolidated data of German air passenger surveys that 31% of German air passengers originate 25km or less from the airport, 56% 50km or less and 72% 75km or less. However, Wilken, Berster and Gelhausen argue, that the distribution and mean values vary strongly by airport – e.g. in Berlin, 85% of passenger travel less than 50km to the airport, while in Frankfurt only 37% travel less than 50km to the airport. Taking the average values of the Wilken, Berster and Gelhausen study, we find that even under very favourable assumptions, the 31% of passengers living most closely to the airport will need at least 60 minutes from their trip origin to scheduled departure time, when travelling up to 25km to the airport by the fastest available access mode, going through the airport processes and presenting themselves for boarding at the gate.

The DATASET2050 project provides some further insight on the distribution of airport access and process times. The authors of the project disaggregate access time ("door to kerb") and process time ("kerb to gate"). Over all categories of travelers, the authors of the DATASET2050 project find that the average door to kerb travel time is 33 minutes, but the kerb to gate time adds up to 114 minutes for all travelers, hence the door to gate travel time exceeds on average 147 minutes (Innaxis, 2019). For the arrival process, the authors of DATASET2050 find an average of 31 minutes for "gate to kerb" and 28 minutes for "kerb to door", so the combined average arrival process and egress time adds up to 59 minutes. However, the methodology of calculating access and egress times in DATASET2050 is not based on surveys, but on a population grid around each of the 22 airports analysed in combination with travel time queries through Google's Distance Matrix API (Rothfeld et al., 2017.). While still the specifities of each airport and each traveler category (e.g. business travelers have less baggage and probably access to the security fast lane resulting in lower process times) have to be regarded, the figures provided by Wilken, Berster and Gelhausen as well as DATASET2050 provide a good overview over empirically found access, egress and process times.

The sensitivity analysis in combination with empirical findings on average airport access, egress and process times shows that the achievement of the Flightpath 2050 connectivity goal is illusory. If – on average - only 30min access and 15min egress time are assumed, which is far from reality, some 82.4% of trips would take less than four hours door-to-door, which is more than seven percentage points below the goal of 90%. If more realistic access and egress time assumptions are applied, the level of goal achievement collapses further and goes down to just 5.9% if 120min and 60min are assumed, respectively.

6. Conclusions & Outlook

The analysis has shown that even under favorable conditions, the achievement of the 4-hour-goal seems to be very difficult. Our results are in line with those coming from DATASET2050 when assuming that passengers will need between 165 and 180 minutes for airport access, egress and processes. Interestingly, air trips in the EU are relatively long, as 46.9% of trips exceed 1000km, and 12.8% of trips exceed 2000km. Hence, from the current structure of intra-EU travel alone, we conclude that the 4-hour-goal cannot be achieved because of the distances in combination with the cruise speed of sub-sonic airliners. The key benefit of our approach is that data can be easily analysed, so that indicators can be calculated which allow monitoring the achievement of the 4-hour-goal. Assumptions on flight times, number of non-stop connections, airport-to-airport travel times (which includes transfer times, airport process times and flying speed) can be included and sensitivity analyses can be conducted.

Hence, based on these findings, a critical assessment and potentially amendment of the 4-hour-goal should take place. Particularly the question should be discussed, whether the 4-hour-goal is reasonable to maintain, when all scientific evidence so far shows that it is very unlikely to achieve it with reasonable means. The achievement of the 4-hour-goal would require either a dense network of supersonic transport technologies in the air or Hyperloop-like ground transport infrastructures. Both developments are relatively unlikely to develop into a mass phenomenon, as supersonic transport is extremely energy-intensive and the sonic boom may prohibit the application over land. Hyperloop would require massive investments in a completely new transport mode on every city pair where the service should be offered. Alternatively, the level of goal achievement could potentially be increased by an over-proportional growth of shorter distance trips, as the growing share of longer trips makes the achievement of the goal with conventional technologies impossible. However, the empirical evidence is that the average distance per trip grows and at the same time, increasing efforts are undertaken to reduce or avoid short distance air trips. So average distance travelled by air is more likely to grow than to decline. It is more realistic to come closer to the 4-hour-goal with an improvement of airport processes (e.g. through new, security concepts prohibiting queues) and faster airport access and egress transport modes, instead of changes to the scheduled air transport network.

Finally, an increased small air transport network, operating non-stop from a large number of airports and airfields with less congestion, faster processes and shorter access and egress times to nearby communities could positively influence the goal achievement. The authors are aware that the methodology applied in this paper lacks a clear understanding of the actual origin and destination passenger demand for intra-European trips. With a better understanding of the actual origins and destinations, the contribution of innovative concepts, such as on-demand autonomous air taxis for inter-city travel or urban air mobility as new airport access mode could be evaluated much better than the approach presented in this paper. A more sophisticated extension of our modelling approach would consider actual access / egress modes and associated travel times, as is done e.g. in airport choice modelling (see, e.g., Gelhausen, 2007). Further insights into the travel behavior of air passengers could be won by mobile phone location data, which so far have been used predominantly for improving the accuracy of intra-urban traffic analyses (e.g. Larijani et al., 2015), but they could also be used as an innovative approach in air transport research. Other European research projects in the past have collected, processed and re-distributed origin-destination traveler data, e.g. ETISplus (European Transport policy Information System Developement and implementation of data collection methodology for EU transport modelling). Along this rationale, further collaborative research projects on European level could address the particular aspect of air traveler behavior, airport access and the structure of airport catchment areas. Such an endeavor could have positive impacts not only on the analysis of the 4-hour-goal, but could generally improve the understanding of mobility patterns and actual needs of European citizens.

References

ACARE, 2017. Strategic Research & Innovation Agenda 2017 Update, Volume 1.

ATAG (Air Transport Action Group), 2005. The economic & social benefits of air transport. https://www.icao.int/meetings/wrdss2011/documents/jointworkshop2005/atag_socialbenefitsairtransport.pdf [Last Access 3rd May, 2019].

Bel, G., Fageda, X., 2008.Getting there fast: globalization, intercontinental flights and location of headquarters. Journal of Economic Geography 8 (4), 471-495.

Burghouwt, G. & Redondi, R., 2013. Connectivity in Air Transport Networks: An Assessment of Models and Applications. Journal of Transport Economics and Policy (47), 35-53.

Dimitriou, D., Sartzetaki, M., 2018. Assessing air transport socio-economic footprint. International Journal of Transportation Science and Technology 7, 283–290.

European Commission, 2010. EUROPE 2020 – A strategy for smart, sustainable and inclusive growth, Communication form the Commission, COM(2010)2020, Brussels, 3.3.2010.

European Commission, 2011. Flightpath 2050 Europe's Vision for Aviation, Report of the High Level Group on Aviation Research. DOI: 10.2777/50266.

European Commission, 2012. TRIMIS - Transport Research and Innovation Monitoring and Information System, European Transport Policy Information System Developement and Implementation of Data Collection Methodology for EU Transport Modelling, https://trimis.ec.europa.eu/project/european-transport-policy-information-system-developement-and-implementation-data-collection [Last Access 6th May 2019].

EUROSTAT, 2016. Statistics on commuting patterns at regional level. https://ec.europa.eu/eurostat/statistics-explained/index.php/Statistics_on_commuting_patterns_at_regional_level#General_overview [Last Access 2nd May 2019].

Gelhausen, M.C., 2007. Passengers' Airport Choice. Proceedings of the Aachen Aviation Convention (AAC) 2007, 41-51.

Gillen, D., Landau, S., Gosling, G.D., 2015. Measuring the Relationship Between Airline Network Connectivity and Productivity. Transportation Research Record: Journal of the Transportation Research Board 2501, 66-75.

Krein, A., Williams, G., 2012. Flightpath 2050: Europe's Vision for Aeronautics. In: Knörzer, D., Szodruch, J. (Eds.), Innovation for Sustainable Aviation in a Global Environment. IOS Press, pp. 63-71.

Innaxis, 2017. Data driven approach for a seamless efficient travelling in 2050 (DATASET2050), D5.2: Assessment Execution. https://s3.eu-central-1.amazonaws.com/innaxis-comm/DATASET2050/D5.2+DATASET2050.pdf [Last Access 8th April 2019].

Innaxis, 2019. D2D Travel time distribution. http://visual.innaxis.org/dataset2050/d2d-time-distribution/ [Last Access 27th August 2019].

Intervistas, 2014. Viability Assessment of Long Haul Service at Wellington Airport. http://www.connectwellington.co.nz/static/documents/Technical%20Report%202.pdf [Last Access 7thJune 2018].

Larijani, A. N., Olteanu-Raimond, A.-M., Perret, J., Brédif, M., Ziemlicki, C., 2015. Investigating the Mobile Phone Data to Estimate the Origin Destination Flow and Analysis; Case Study: Paris Region. Transportation Research Procedia Volume 6, 2015, Pages 64-78.

Maertens, S., Pabst, H., Grimme, W., 2016, The scope for low-cost connecting services in Europe — Is self-hubbing only the beginning?

Research in Transportation Business & Management 21, 84-93.

Nieße, H., Grimme, W., 2014. Minimum Travel Times between European Regions – An assessment of the ACARE 4h-Goal, Proceedings of the ATRS Conference 2014.

Rothfeld, R., Straubinger, A., Paul, A., Plötner, K., 2017. Analysis of European Airports' Access and Egress Travel Times using Google Maps. Air Transport Research Society World Conference 2017.

Sabre, 2014. Sabre AirVision Market Intelligence, Version 5.7. User Guide.

Wilken, D., Berster, P., Gelhausen, M., 2007. Airport choice in Germany: New empirical evidence of the 2003 German air traveller survey. Journal of Airport Management Vol. 1, No. 2, 165-179, January-March 2007.